

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 9/9/2011 has been entered.

Remarks

Claim 1 and 11 are amended. Claims 1-7, 9 and 11 are currently pending.

Status of Rejections

All rejections from the previous office action are withdrawn in view of Applicant's amendments. New ground of rejection is presented as necessitated by amendment.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

3. The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

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2. Ascertaining the differences between the prior art and the claims at issue.
 3. Resolving the level of ordinary skill in the pertinent art.
 4. Considering objective evidence present in the application indicating obviousness or nonobviousness.
4. Claims 1-2, 5-7, 9 and 11 are rejected 35 U.S.C. 103(a) as being unpatentable over Ding (*"Nanofabrication of Organic/Inorganic Hybrids of TiO₂ with Substituted Phthalocyanine or Polythiophene"*), Zhao (*Polymer brushes: surface immobilized macromolecules*) and Sicot (*Dye sensitized polythiophene solar cells*).

As to claim 1, Ding teaches a method of preparing a pn—semiconductor material that can be obtained by the following steps: providing a substrate, a step in which a substrate made of porous oxide ceramic (porous TiO₂ nanoparticles – section I, ¶ 2) is functionalized by chemical grafting of one or more compounds containing at least one group (carboxylic groups, sulfonic acid groups- section I, ¶ 3) that can be polymerized with one of more precursors of an electrically conducting polymer (PTAA - section I, ¶ 3) and at least one group able to be chemically grafted (covalent linkage - section I, ¶ 3) onto said substrate; and a step in which the substrate thus functionalized is impregnated with a solution containing an electrically conducting polymer (section 3.1.2., ¶ 1). The Examiner notes that TiO₂ is the n-type material and the conducting polymer the p-type material. Ding is silent to a step in which the substrate thus functionalized being impregnated with a solution containing the precursor(s); and a step in which the precursor(s) are polymerized.

Zhao teaches a conventional chemical grafting method (grafting from) that requires the step of first providing a substrate, then functionalizing the surface (I, initiators) and finally impregnating with a solution of precursors (M, monomers) which

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are then polymerized (Figure 9). Zhao teaches that the advantage of using 'grafting from' rather than the method taught by Ding (grafting to, functionalizing, then directly linking polymer) is that there is an increase in grafting density using 'grafting from', as taught by Zhao (page 693 and 695, section 4). Zhao teaches that the methods of adsorption, grafting to and grafting from, are art recognized and conventional methods of forming tethered/grafted polymers from substrates. Taking the references as a whole, it would have been obvious to one of ordinary skill in the art at the time of the invention to use the 'grafting from' method of Zhao in Ding because 'grafting from' decreases the amount of steric hindrance because the precursor (monomers) are smaller molecules than polymers and can readily reach the substrate to covalently link (Zhao: page 695) especially in light of the fact that Ding teaches that increased density of conducting polymer maximizes efficiency (section 1, ¶ 2).

Further regarding claim 1, Ding teaches that sensitization of the semiconductor with dye (chromophores) or conjugated polymers is well known in the art (section 1, ¶ 1) and that the semiconductor (titanium oxide) of Ding can be sensitized with dye or conducting polymer (polythiophene/precursors) using the novel route comprising covalent linkages (grafting) (section 1, ¶ 3) but is silent to the sensitization semiconductor (titanium oxide) with polymer in the presence of dye at the same time.

Sicot teaches that photoconductive polymers are not able to absorb photons over the entire solar spectrum such that dye sensitization is used to enlarge the spectral response of solar cells (section 1, ¶ 1), specifically Sicot is directed to polythiophene conducting polymers (same class of polymers used by Ding) in the presence of dye

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(figure 1). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine dye and conducting polymer in Ding because the combined sensitization provides an enlarged spectral response which sharply affects the power conversion efficiency, as taught by Sicot (section 1, ¶ 1). One of ordinary skill in the art would appreciate that the dye molecules are smaller than the polymers such that it would have been obvious to try first sensitizing with dye (functionalizing with precursors in the presence of dye) choosing from a finite number of predictable solutions (first dye then precursor and first precursor then dye) with a reasonable expectation of success (MPEP 2141) especially since subsequent polymerization would sterically hinder the smaller dye molecules (analogous to discussion above and Zhao: page 695) and selection of any order of performing process steps is prima facie obvious in the absence of new or unexpected results (MPEP 2144).

Regarding claims 2 and 5, modified Ding teaches that the ceramic is TiO_2 (Ding: section 1, ¶ 2).

Regarding claim 6, modified Ding teaches that the group able to be chemically grafted onto the ceramic is COOR^1 where R^1 represents a hydrogen atom (carboxylic groups) or phthalocyanine tetrasulfonic acid tetrasodium salt $\text{SO}_3\text{M}'$ (Ding: section 1, ¶ 3).

Regarding claim 7, modified Ding teaches that the group chosen COOR^1 and $\text{SO}_3\text{M}'$ can be polymerized with precursors (Zhao: see claim 1) of an electrically conducting polymer chosen group thiophene (PTAA) (Ding: section 1, ¶ 3).

Regarding claim 9, modified Ding teaches that the porous oxide ceramic substrate is TiO_2 chemically grafted by thiophene-3-acetic acid (if the polymer directly bonds to the substrate then the link between the substrate and the polymer less one unit will be a monomer of the polymer which is thiophene-3-acetic acid) to an alkylthiophene (remainder of the PTAA) (Ding: Figure 1). Therefore, in the event of using 'graft from' the first linkage between a monomer and the porous oxide will provide the functionalization with the required formula followed by polymerization with the remainder of the monomers, alkylthiophenes to produce grafted PTAA. As discussed above in relation to claim 1, it would have been obvious to one of ordinary skill in the art to use "graft from" because 'grafting from' decreases the amount of steric hindrance because the precursor (monomers) are smaller molecules than polymers and can readily reach the substrate to link (Zhao).

Regarding claim 11, modified Ding teaches the use of the pn-semiconductor material comprising a porous metal oxide ceramic chemically grafted to an electrically conducting polymer grafted thereto for use in a solar cells (Ding: section 1, ¶ 1), but is silent to the pn-semiconductor material being between the electrodes. It would have been obvious to one of ordinary skill in the art to at the time of the invention to place the pn-semiconductor material between a first and second electrode in the solar cell because otherwise the solar cell would not function.

5. Claims 3-4 and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ding and Zhao as applied to claim 1 above, and further in view of O'regan (*A low cost, high efficiency solar cell based on dye sensitized colloidal TiO_2 films*).

Regarding claim 3, modified Ding does not specify that the nanoparticles are mesoporous. O'Regan teaches mesoporous (2-50nm) nanoparticles (page 738, ¶ 3). It would have been obvious to one of ordinary skill in the art at the time of the invention to use the mesoporous nanoparticles of O'Regan in Ding because the optimum diameter value of pores that results from a compromise between increased surface area (more smaller pores) and large enough diameter to decrease steric hindrance effects during polymerization) is a result effective variable that involves only routine skill in the art especially in light of the fact that the porous oxide films of O'Regan display exceptionally high efficiencies (abstract).

Regarding claim 4, Ding teaches that the nanoparticles are mesostructured (network of porous nanoparticles) (section I, ¶ 2).

Regarding claim 11, modified Ding teaches the use of the pn-semiconductor material comprising a porous metal oxide ceramic chemically grafted to an electrically conducting polymer grafted thereto for use in a solar cells (section 1, ¶ 1), but is silent to the pn-semiconductor material being between the electrodes. It would have been obvious to one of ordinary skill in the art to at the time of the invention to place the pn-semiconductor material between a first and second electrode in the solar cell because otherwise the solar cell would not function.

Response to Arguments

Applicant's arguments with respect to claim 1 and O'Regan have been considered but are moot in view of the new ground(s) of rejection as necessitated by amendment.

Contact Information

Any inquiry concerning this communication or earlier communications from the examiner should be directed to **MIRIAM BERDICHEVSKY** whose telephone number is (571)270-5256. The examiner can normally be reached on M-Th, 10am-8pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Alexa Neckel can be reached on (571) 272-1446. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MIRIAM BERDICHEVSKY/

Examiner, Art Unit 1723